Hackathon Project Guide

AI for Mapping Landslide Prone Areas

1. Title

"AI Powered Landslide Risk Assessment and Mapping System"

2. Background for participants

Recent Examples in Uttarakhand

1. **ISRO Landslide Atlas: Rudraprayag & Tehri Most Prone**

   ISRO / NRSC data identifies *Rudraprayag* and *Tehri Garhwal* as the two most landslide-dense and high risk exposure districts in India. Uttarakhand had ~11,219 landslides from 1988–2022 according to that dataset.

2. **IIT Roorkee's District-Wise Hazard Mapping**

   IIT Roorkee mapped vulnerability in Uttarakhand to earthquakes **and** landslides. In this, *Rudraprayag* came out as the most vulnerable district; followed by *Pithoragarh, Chamoli,* and *Uttarkashi*. The study uses seismic intensity (PGA) scenarios to see how likely earthquake-triggered landslides are.

3. **Landslide Susceptibility Mapping in Mussoorie**

   WIHG study for Mussoorie and surroundings (~84 km²) shows ~15% of the area is **highly susceptible** to landslides. They used factors like lithology, slope, aspect, curvature, elevation, lineament, road cuts,

land use/land cover, etc., and validated using Success Rate Curve (SRC) and Prediction Rate Curve (PRC). AUC values were ~0.75 (SRC) and ~0.70 (PRC).

4. **Early Warning Systems & Government Initiatives**

   Uttarakhand is pushing for landslide early warning systems, especially in *Uttarkashi, Chamoli, Rudraprayag,* Tehri etc.

   Also, after recent monsoon / deluge events, surveys and risk assessments are being carried out.

5. **Char Dham Route & Hill-Cutting Impacts**

   A recent study finds a rise in landslide incidents along the Char Dham highway route in Uttarakhand. Many of these are linked to *unscientific hill cuts*, steep slopes cut for road widening, poor drainage, etc.

6. **Landslide Dams / Natural Dams**

   Studies highlight that **Chamoli district**, *followed by Rudraprayag and Uttarkashi*, are particularly vulnerable to landslide dams (i.e. landslides blocking rivers), which pose risks of catastrophic outburst floods.

7. **Earthquake-induced Landslide Risks**

   The IIT study warns that certain districts are under seismic stress and likely to have significant earthquake-triggered landslides. Rudraprayag is especially highlighted.

2. Problem Statement

Landslides cause significant loss of life, property damage, and infrastructure disruption worldwide. Traditional landslide risk assessment methods rely on manual surveys and historical data, which are time consuming and often lack real-time predictive capabilities. There is a need for an AI-driven solution that can:

a. **Predict landslide-prone areas** using geospatial and environmental data.
b. **Provide real-time risk alerts** to authorities and communities.
c. **Improve disaster preparedness** with high accuracy mapping.

3. Proposed Solution

The participant can propose an AI based landslide risk mapping system that:

- Uses machine learning (ML) and deep learning (DL) to analyze satellite imagery, rainfall data, soil type, slope, and vegetation cover.
- Integrates GIS (Geographic Information Systems) for spatial analysis.
- Generates risk heatmaps to identify high, medium, and lowrisk zones.
- Provides a web-based dashboard for government agencies and disaster management teams.

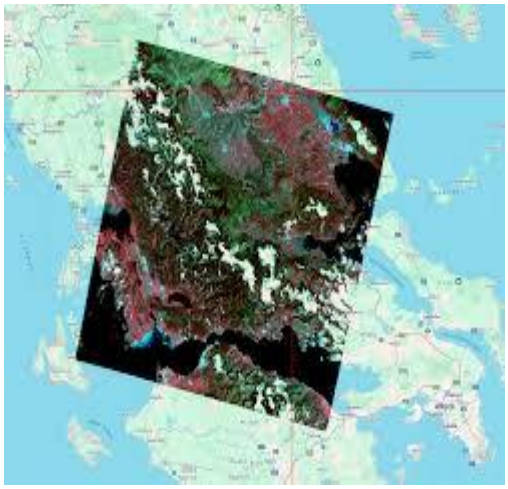
4. Tools/Technology

AI/ML Models:

1. Random Forest, SVM, CNN (for image classification)
2. Tensor Flow/PyTorch (for deep learning)

Geospatial Tools:

1. QGIS, Google Earth Engine
2. ArcGIS API (for mapping)



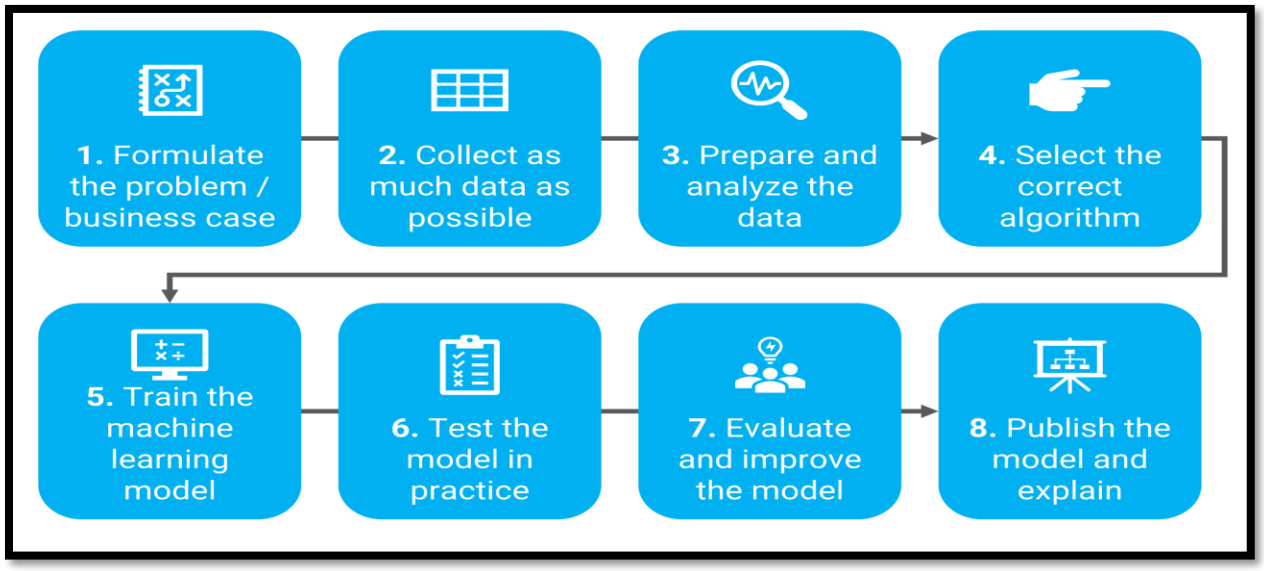
Data Sources:

1. Satellite imagery (Sentinel2, Landsat)
2. DEM (Digital Elevation Model) data
3. Rainfall and soil moisture datasets (NOAA, NASA)

Development Tools:

1. Python (Geopandas, Rasterio, Scikitlearn)
2. Flask/Django (for web dashboard)
3. JavaScript/Leaflet.js (interactive maps)

5. Methodology



We shall follow the above methodology and move forward in phases as mentioned below:

Phase 1: Data Collection & Preprocessing (Data exploration, preprocessing, feature extraction.**)**

1. Gather historical landslide data (past incidents, locations).
2. Collect satellite images, DEM, soil, and rainfall data.
3. Clean and preprocess data (normalization, feature extraction).

Phase 2: Model Development

1. Train ML models (Random Forest, SVM) on geospatial features.
2. Implement CNN for terrain image classification.
3. Validate models using cross validation and accuracy metrics.

Phase 3: Risk Mapping & Visualization (: Visualization, dashboard development**)**

1. Generate landslide susceptibility maps using GIS tools.
2. A **web dashboard** with interactive risk visualization.
3. Integrate realtime weather updates for dynamic risk assessment.

Phase 4: Add Evaluation Metrics

Participants should know how to evaluate their model:

- **Classification metrics**: Accuracy, Precision, Recall, F1-score (for landslide vs. no-landslide).
- **Spatial metrics**: AUC-ROC, Cohen's Kappa, Intersection-over-Union (IoU).
- **Risk maps**: Visual comparison with historical landslide events.

Phase 5: Deployment & Testing

1. Deploy the model on a cloud platform (AWS/GCP).
2. Test in a real-world scenario (e.g., hilly regions like the Himalayas).
3. Refine model based on feedback.

6. Important Tips for Participants

I. You can choose Rudraprayag, Chamoli, Uttarkashi, Tehri as priority pilot regions since they appear frequently in high-risk studies.
II. Use real government / satellite data like ISRO's Landslide Atlas and the IIT Roorkee vulnerability maps as baseline.
III. Factor in road-cutting, slope steepness, drainage etc. — these show up repeatedly as causal factors in local studies.
IV. For model validation use AUC, SRC/PRC etc., since they have been used locally (e.g. Mussoorie case).
V. Consider integrating seismic risk (if possible), especially for earthquake-induced landslides (some studies do this).
VI. Transfer Learning: Use pretrained CNNs (ResNet, EfficientNet) on terrain/satellite imagery.
VII. Ensemble Models: Combine Random Forest (tabular geospatial features) with CNN (image features).
VIII. Explainable AI**:** Use SHAP or LIME to explain which factors (slope, rainfall, vegetation) most influence landslide predictions.
IX. Mobile App Integration: Push community alerts in high-risk zones.

7. Presentation Template (for Final Pitch) must include:

I. Problem Statement
II. Dataset Used
III. Approach (ML/DL + GIS tools)
IV. Results (accuracy + sample risk maps)
V. Demo of Dashboard/Visualization
VI. Future Scope

8. Resources

Some of the high quality web resources to support your "Mapping Landslide Prone Areas Using AI" are mentioned below:

[1] GeoHackWeek. (n.d.). *Land-slide-detection* [GitHub repository]. GitHub. https://github.com/geohackweek/land-slide-detection
[2] QGIS Tutorials and Tips. (2019, October 15). *Machine learning in QGIS* [Video]. YouTube. https://www.youtube.com/watch?v=9d66jZ7K6yI
[3] Wang, Y., Fang, Z., & Hong, H. (2021). Deep learning for landslide susceptibility mapping. *Scientific Reports, 11,* 24112. https://doi.org/10.1038/s41598-021-03585-1
[4] Sharma, L. P., Patel, N., & Ghose, M. K. (2021). Using AI to predict landslides in the Himalayas. *IEEE Geoscience and Remote Sensing Letters, 19,* 1–5. https://doi.org/10.1109/LGRS.2021.3064162
[5] UNESCO. (2020). *Landslide risk mitigation: A guide for practitioners*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000374245
[6] Google. (n.d.). *Google Earth Engine platform*. https://earthengine.google.com/
[7] TensorFlow. (n.d.). *Land cover segmentation tutorial*. https://www.tensorflow.org/hub/tutorials/landcover_segmentation
[8] Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., … Duchesnay, É. (2011). Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research, 12,* 2825–2830. https://scikit-learn.org/stable/
[9] Gillies, S., & others. (n.d.). *Rasterio: Geospatial raster I/O for Python programmers*. https://rasterio.readthedocs.io/
[10] University of Toronto. (n.d.). *Geospatial artificial intelligence* [Online course]. Coursera. https://www.coursera.org/learn/geospatial
[11] Outlook India. (2023, March 30). *Rudraprayag, Tehri in Uttarakhand have highest risk exposure to landslide: ISRO*. Outlook. https://www.outlookindia.com/national/rudraprayag-tehri-in-uttarakhand-have-highest-risk-exposure-to-landslide-isro-news-268733
[12] Down To Earth. (2023, March 29). *ISRO data shows Uttarakhand's Rudraprayag and Tehri Garhwal most prone to landslides in India*. Down To Earth.

https://www.downtoearth.org.in/natural-disasters/isro-data-shows-uttarakhand-s-rudraprayag-and-tehri-gharwal-most-prone-to-landslides-in-india-88112

[13] India Today. (2025, September 7). *IIT Roorkee maps Uttarakhand's disaster hotspots, Rudraprayag most at risk*. India Today. https://www.indiatoday.in/science/story/iit-roorkee-maps-uttarakhands-disaster-hotspots-rudraprayag-most-at-risk-2783416-2025-09-07

[14] Uttarakhand Himalaya. (2024, January 10). *Landslide susceptibility mapping of Mussoorie and its surrounding areas in Uttarakhand Himalaya*. Uttarakhand Himalaya. https://uttarakhandhimalaya.in/landslide-susceptibility-mapping-of-mussoorie-and-its-surrounding-areas-in-uttarakhand-himalaya

[15] Uttarakhand News Network. (2024, January 11). *Landslide susceptibility mapping of Mussoorie and its surrounding areas*. Uttarakhand News Network. https://uttarakhandnewsnetwork.com/uttarakhand-news/landslide-susceptibility-mapping-of-mussoorie-and-its-surrounding-areas-22833

[16] The New Indian Express. (2025, August 30). *Uttarakhand gears up for landslide early warning systems as monsoon risks escalate*. The New Indian Express. https://www.newindianexpress.com/nation/2025/Aug/30/uttarakhand-gears-up-for-landslide-early-warning-systems-as-monsoon-risks-escalate

[17] Times of India. (2025, August 27). *Post-deluge, teams begin survey of disaster-hit districts*. The Times of India. https://timesofindia.indiatimes.com/city/dehradun/post-deluge-teams-begin-survey-of-disaster-hit-dists/articleshow/124097457.cms

[18] Times of India. (2025, July 14). *Big landslide rise on Char Dham route: Unscientific hill cuts to blame, study finds*. The Times of India. https://timesofindia.indiatimes.com/city/dehradun/big-landslide-rise-on-char-dham-route-unscientific-hill-cuts-to-blame

video links - https://youtu.be/WRy9dczE6E8